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BY

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SULPHUR-SPRAY RESIDUES AND THE SWELLING OF TIN CANS PACKED WITH PEACHES[1]

By C. W. CULPEPPER, *Physiologist*, and H. H. MOON, *Junior Pomologist, Office of Horticultural Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture*

INTRODUCTION

The varieties of peaches generally grown for supplying the fresh-fruit market are sometimes canned in considerable quantities, especially in years of overproduction. Owing to the nature of these varieties and to the warm summer temperature, the fruit ripens rapidly and becomes soft in a very short time after ripening begins. Notwithstanding prompt picking and handling, many peaches arrive at the canning plant too soft to be peeled with the usual lye-peeling machines. Such fruit is generally canned by being washed and packed in the usual way without peeling. Fruit packed in this way is sold as "pie peaches." Since the adoption of the sulphur sprays for the control of the brown-rot fungus, difficulty has been encountered with this material because of the swelling of the cans in a few months after canning. The extent of this loss varies greatly in different years.

At the request of some of the canners at Fort Valley, Ga., the writers undertook some work upon this problem in 1925 with the hope of gaining a better understanding of these difficulties.

LITERATURE

At the beginning of the work it was apparent that the swelling was due to spray residue, for no trouble had been experienced with lye-peeled material packed in the usual way.

Clough, Shostrom, and Clark (*1*)[2] had already shown that a lime-sulphur spray upon gooseberries caused gas formation when such fruit was packed in tin cans. The gas present was mainly hydrogen, but it was always accompanied by more or less hydrogen sulphide. They also found that the gas formation was considerably retarded when the fruit was canned in a heavy sirup.

Stevenson (*9*) has shown that lime-sulphur spray on cherries causes the swelling of the container when they are put up in plain tin cans. He has also shown that difficulty may be encountered in washing the spray residue from the fruit. He refers to one instance of swelling of cans of unpeeled pie peaches caused by lime-sulphur spray.

EXPERIMENTAL WORK

In 1925 and 1926 lots of fruit that showed the presence of adhering spray material were selected from the orchard. A quantity of fruit that had received no spray whatever was also obtained. The

[1] Received for publication February 1, 1929; issued July, 1929.

[2] Italic numbers in parentheses refer to "Literature cited," p. 40.

unsprayed material was canned without peeling, both with and without exhaust. One portion of the sprayed material was canned without being washed; another was canned after being washed in cold water; one was dipped in hot dilute lye (0.1 per cent was used, and at frequent intervals enough was added to keep the solution slightly alkaline) and then washed by being sprayed with jets of cold water; another portion was canned after being lye peeled in the usual way.

In the unsprayed unpeeled lots and in the lye-peeled lots that had been exhausted for four minutes no appreciable swelling occurred in two years. The unsprayed unpeeled lots and the lye-peeled lots that were not exhausted showed about 10 per cent of "flippers" [3] at the end of two years. In the 1925 pack practically all the unpeeled sprayed material that was given an exhaust—that unwashed and that washed in cold water—swelled 8 to 14 months after canning. In the 1926 pack the lots thus treated required several months longer to develop swelling, and some had not swelled at the end of two years. The unexhausted cans of unpeeled sprayed fruit swelled very much sooner, some in a few weeks after canning, and nearly all swelled in two years. The lots washed in dilute lye and exhausted did not swell in two years. The unexhausted cans of fruit that had been washed in dilute lye contained about 10 per cent of "flippers" or "swells" at the end of two years; that is, they behaved about like the unsprayed unexhausted checks. It is clear that an efficient exhaust will greatly prolong the time required for swelling to occur.

It is very evident from these experiments that spray residue is rather hard to wash from the surface of peaches. This seems to be due to the insoluble nature of the spray residue and to the velvet-like covering of plant hairs upon the fruit. Washing with cold water and even with hot water did not seem to be entirely effective. Immersing the fruit in hot dilute lye for a few seconds and then washing with cold water has proved effective during the two years that this treatment has been used. It has been found possible to dip quite soft fruit into hot dilute lye for 15 to 30 seconds and then to remove the lye by spraying with jets of cold water without causing disintegration.

EFFECT OF VARIOUS FORMS OF SULPHUR

Since it is possible that the sulphur may exist upon the fruit in several forms, it seemed advisable to determine which form is responsible for the swelling of the cans. Accordingly, in 1925 five lots of unsprayed peaches were put up in No. 2 plain tin cans to which were added lime-sulphur spray, free sulphur as flowers of sulphur, hydrogen sulphide, sodium thiosulphate, and sodium sulphite, respectively. The quantity of fruit filled into the cans varied from 325 to 350 gm., and the quantity of water added varied accordingly, the total weight of the contents being approximately 540 gm. The lots of cans were divided into two series; one series received the equivalent of 100 mg. of sulphur per can, and the other received the equivalent of 10 mg. The sulphur was added as the fruit was packed in the cans. After the proper quantity of water had been added, the cans were exhausted and sealed. In the case of the hydrogen sulphide the addition was made subsequent to exhausting and just before sealing.

[3] A "flipper" is a can slightly distended with gas; a "swell" is one distended more firmly or to a greater extent.

The cans containing lime-sulphur spray or hydrogen sulphide showed swelling first, whereas those containing sodium thiosulphate were the last to show swelling. The lots canned as checks contained less than 1 per cent of swells at the end of two years. The lots receiving 100 mg. of sulphur in all the above-mentioned forms swelled within two years; those receiving the equivalent of 10 mg. of sulphur—as hydrogen sulphide, sodium sulphite, or in the form of lime-sulphur spray—showed a few swells at the end of the first year of storage, and at the end of two years 10 to 30 per cent of the cans were swollen; those receiving 10 mg. of sulphur as sodium thiosulphate did not show swelling of the cans in two years.

From these tests it is apparent that sulphur in almost any form will cause swelling of the cans and that sometimes very small quantities will suffice to produce this effect.

In 1926 the experiments were repeated, 100 mg. of sulphur per can being used in the forms employed in the preceding year, and in addition ferrous sulphide and sulphurous and sulphuric acid were included. These were canned both in cans that were exhausted and in unexhausted cans. The unexhausted cans containing sulphur swelled in a very short time, and even the unsprayed checks that were not exhausted developed a few flippers at the end of two years. The properly exhausted cans usually required several months longer to swell. According to MacInnes and Contieri (*5*), hydrogen overvoltage is increased when the gas pressure is decreased. Hence, properly exhausted cans liberate hydrogen with less ease than unexhausted cans. Sodium sulphide, ferrous sulphide, and sulphurous acid caused swelling of the cans, as did the other forms of sulphur. The sulphuric acid sometimes caused swelling, but frequently the cans pinholed before swelling.

It appears from these experiments that it is not hydrogen sulphide alone that causes the swelling. The gas present in the cans is largely hydrogen. The small quantity of hydrogen sulphide present accelerates the liberation of hydrogen caused by the action of the acids of the fruit on the metal of the container.

CORROSIVE ACTION OF SULPHUR ON THE CAN

In examining the lots of cans it was observed that the cans containing sulphur-sprayed fruit or having other forms of sulphur added to the fruit in the can appeared to be much more corroded than the check lots. It appeared that to a considerable extent the gas formation resulted from increased action of the fruit acids on the can.

To throw further light upon the mechanism of swelling and the corrosive action of sulphur upon the can, certain lots of cans were carefully weighed and filled with water or with 0.5 per cent citric acid. Citric acid in this concentration was used because it is the principal acid of the peach and because the total acidity is approximately of a concentration corresponding to 0.5 per cent citric acid. Various forms of sulphur were then added and the cans processed in the usual way, either with exhaust for three minutes or without any exhaust whatsoever. At the end of three months the cans were examined, one end was removed by a smooth cut, the cans were washed, dried, and again weighed. The loss in weight represents the extent of the corrosion that occurred. Much black sulphide

adhered to the cans receiving sulphur. This was removed by adding a little hydrochloric acid to the can for a few seconds and then quickly washing off the acid with water, drying, and weighing. Detailed notes were taken upon the appearance of the container, the odor of the contents, and the presence or absence of gas formation in the can. The results are shown in Table 1.

TABLE 1.—*Corrosive action of various forms of sulphur upon the tin can*

Substance added to the can	Treatment	Condition as to swelling	Odor of H_2S	Black discoloration	Perforation	Loss of weight per can (grams)
H_2O	3 minutes exhaust	Normal	Absent	Absent	Absent	0.011
0.5 per cent citric acid	do	do	do	do	do	.069
	No exhaust	do	do	do	do	.117
0.5 per cent citric acid and 50 mg. sulphur.	3 minutes exhaust	Swelled	Present	Present	do	.525
	No exhaust	do	do	do	do	.662
0.5 per cent citric acid and 100 mg. sulphur.	3 minutes exhaust	do	do	do	do	.679
	No exhaust	do	do	do	do	.651
	Head space filled with nitrogen.	do	do	do	do	.898
	Head space filled with hydrogen.	do	do	do	do	.838
	Head space filled with oxygen.	do	do	do	do	.787
Distilled water and 100 mg. sulphur.	3 minutes exhaust	Normal	Faint	do	do	.156
	No exhaust	do	do	do	do	.176
0.5 per cent citric acid and 100 mg. sulphur as hydrogen sulphide.	do	Swelled	Present	do	60 per cent	.775
Distilled water and 100 mg. of sulphur as hydrogen sulphide.	do	Normal	Faint	do	Absent	.089
0.5 per cent citric acid and 400 mg. sodium hydrogen sulphite.	3 minutes exhaust	Swelled	do	do	do	1.161
	No exhaust	do	do	do	do	1.095
Distilled water and 400 mg. sodium hydrogen sulphite.	3 minutes exhaust	Normal	Absent	do	do	.237
	No exhaust	do	do	do	do	.270
0.5 per cent citric acid and 300 mg. sodium thiosulphate.	3 minutes exhaust	Swelled	Faint or absent.	do	do	1.201
	No exhaust	do	do	do	do	1.206
0.5 per cent citric acid and 5 c. c. of 5 per cent sulphurous acid.	3 minutes exhaust	do	do	do	20 per cent	.974
	No exhaust	do	do	do	Absent	1.050
Distilled water and 5 c. c. of 5 per cent sulphurous acid.	3 minutes exhaust	Normal	Absent	do	do	.193
	No exhaust	do	do	do	do	.481
0.5 per cent citric acid and 500 mg. ferrous sulphide.	3 minutes exhaust	Swelled	Present	do	20 per cent	1.327
	No exhaust	do	do	do	do	1.050
Distilled water and 500 mg. ferrous sulphide.	3 minutes exhaust	Normal	Absent or faint.	Absent	Absent	.020
	No exhaust	do	do	do	do	.025
0.5 per cent citric acid and 500 mg. stannous sulphide.	3 minutes exhaust	20 per cent flippers.	do	Present	do	.363
1 per cent citric acid and 500 mg. stannous sulphide.	do	do	Faint	do	40 per cent	.674

It is evident from Table 1 that the properly exhausted cans containing citric acid were not greatly corroded but that the unexhausted cans were somewhat more severely attacked. The quantities of sulphur used caused much corrosion, and exhausting seemed to make comparatively little difference in the result. The same is true with cans in which the head space was filled with nitrogen, hydrogen, or oxygen. In most cases where sulphur had been added at least a faint odor of hydrogen sulphide was present. It was always more pronounced in cans containing acid and was faint or absent in cans filled with sulphur and distilled water. Perforations occurred in several lots, and undoubtedly many more would have developed had the experiment been continued longer.

It is noted that no swelling occurred where distilled water and sulphur were canned together, whereas the cans filled with 0.5 per

cent citric acid with sulphur added invariably swelled. It is apparent that the acid of the fruit is the primary cause of the formation of the gas. The sulphur seems merely to accelerate a tendency already present. The cans containing sulphur in such forms that it could combine with the metal of the container, however, were corroded regardless of the presence of the acid. For example, hydrogen sulphide corroded the can whether acid was present or not, but it did not swell the can unless acid was present. Ferrous sulphide in the presence of acid severely corrodes and causes swelling of the can, but when it is canned with water no corrosion and no gas formation occurs.

These experiments indicate that the spray residue reacts upon the metal of the container to form sulphides. If acid is present the metallic sulphides are decomposed and hydrogen sulphide is formed, at least to a small extent. The hydrogen sulphide thus liberated accelerates the liberation of hydrogen gas as a result of the action of the acid upon the metal of the container.

LIBERATION OF GAS FROM IRON AND TIN

To determine whether the formation of the hydrogen gas was the result of the action of the acids upon the tin or the iron of the can, strips of steel plate, such as are used in the manufacture of cans, and plates of block tin of equal size were immersed in citric acid or water in Ehrlenmeyer flasks, with ordinary burettes so attached that any gas formed could easily be detected and measured. In another set of flasks with iron and tin immersed in citric acid the changes in pressure in the flasks were measured by means of manometers. From the changes in pressure the quantity of gas formed could be computed. The two methods agreed in their general result. A number of these tests were set up with the addition of various forms of sulphur, and in no case were appreciable quantities of gas liberated from tin. This is probably due to the high overvoltage of hydrogen on tin, as shown by Newbery (*7*). If oxygen was present the pressure in the flasks was lowered, indicating the absorption of that element. No appreciable quantity of hydrogen was liberated from iron in distilled water, but hydrogen was liberated from iron immersed in 0.5 per cent citric acid whether sulphur was present or not. Liberation of hydrogen was always much more rapid in the presence of sulphur.

The foregoing experiments show that citric acid of the concentration present in the peach will cause hydrogen-gas formation when in contact with iron alone.

ELECTROCHEMICAL NATURE OF THE CORROSIVE PROCESS

Since the iron of the tin can is more or less imperfectly covered with tin, it seems desirable to know why the fruit rarely causes swelling in the absence of sulphur although there is corrosion and gas formation when small quantities of sulphur are present. This seems to find rather adequate explanation in the electrochemical theory of corrosion (*2, 8, 11*).

To discover what effect the placing of the metals iron and tin in contact would have upon the nature and extent of corrosion when immersed in peach juice, an experiment was carried out wherein 700 c. c. of juice from the Belle variety was placed in each of four

ordinary fruit jars. In the first jar a piece of iron 3 by 4 inches (7.5 by 10 cm.) such as is used in the manufacture of tin cans was placed; in the second, a piece of block tin of equal size was placed; in the third, a piece of iron and a piece of tin were placed but not in contact; in the fourth, pieces of iron and tin firmly in contact were placed. The jars were then put into a retort and steamed for 20 minutes, after which the clips were snapped down, sealing the jar. By this method most of the oxygen was excluded. Before the pieces of tin and iron were introduced into the jars, the metals were carefully cleaned with hydrochloric acid, dried, and weighed.

At the end of six months the experiments were terminated, and the strips of iron and tin ware washed, dried, and weighed again. In the first jar the iron (alone) lost 0.555 gm.; the tin (alone) in the second jar lost 0.009 gm. In the third jar with the two metals not in contact the iron lost 0.167 gm. and the tin lost 0.164 gm.; in the fourth jar with the metals in contact the iron lost 0.038 gm. and the tin lost 0.212 gm. It is evident that the iron is greatly protected from corrosion by contact with tin, and that tin in contact with iron is subjected to much greater corrosion. These results are in general agreement with the findings of Kohman (*3*) and also with those of Lueck and Blair (*4*). It is noted that the total corrosion occurring in the fourth jar is somewhat less than the total in the third jar and much less than in the first jar, with iron alone. It appears that the iron is protected to some extent when tin is present in the same vessel, even when they are not in contact. These tests would indicate that tin is anodic to iron when they are used as electrodes in a galvanic cell with peach juice as the electrolyte. The tin behaves as the dissolving electrode in such a cell. This would indicate that in ordinary canning operations iron is generally cathodic to tin.

A cell containing peach juice as electrolyte and iron and tin as electrodes was set up. The resulting potential was small, but consistently indicated that iron was cathodic to tin. If there were ferric ions in the electrolyte this result is just what would be expected from their position in the electrochemical series. In accordance with the normal electrode potentials (*10*), divalent iron is above tin and trivalent iron below tin in the electrochemical series. Since oxygen was present to some extent in the cells heretofore described, it seems probable that enough ferric iron was present to give the polarity indicated.

EFFECT OF OXYGEN AND SULPHUR ON POLARITY OF IRON AND TIN

To show the effect of oxygen and sulphur on the polarity of iron and tin, the cells indicated in Table 2 were set up.

The electrode vessels used were wide-mouthed jars fitted with rubber stoppers. These were filled about three-fourths full of citric acid (700 c. c.) as electrolyte. The acid was boiled just previous to being placed in the jars. Through the rubber stoppers a 0.5 per cent citric acid-agar bridge connecting the vessels containing the electrodes was inserted. The electrodes were carefully cleaned with hydrochloric acid, washed with distilled water, wiped with a clean dry towel, and immediately dried for a short time in an oven. They were then inserted through the rubber stoppers. Glass stopcocks were also inserted through the stoppers to pass nitrogen or oxygen

through the electrode vessels as desired. Where the presence of sulphur is indicated, 0.3 gm. of flowers of sulphur was added to the electrode vessel. A little hydrogen sulphide was also added at the time the electrodes were inserted. The cells thus set up were kept in a room with a constant temperature of 30° C.

Diagram indicating the polarity of iron and tin under varying conditions

No.	Diagram of cell				Resulting polarity
1	Iron	Citric acid, oxygen excluded.	0.5 per cent citric acid, agar-agar bridge.	0.5 per cent citric acid, oxygen excluded.	Tin	Iron anodic at first, but became cathodic.
2	Iron	0.5 per cent citric acid, oxygen present.	0.5 per cent citric acid, agar-agar bridge.	0.5 per cent citric acid, oxygen excluded.	Tin	Iron cathodic.
3	Iron	0.5 per cent citric acid, oxygen excluded.	0.5 per cent citric acid, agar-agar bridge.	0.5 per cent citric acid, oxygen present.	Tin	Iron anodic.
4	Iron	0.5 per cent citric acid, sulphur present, oxygen excluded.	0.5 per cent citric acid, agar-agar bridge.	0.5 per cent citric acid, sulphur present, oxygen absent.	Tin	Iron anodic
5	Iron	0.5 per cent citric acid, sulphur present, oxygen absent.	0.5 per cent citric acid, agar-agar bridge.	0.5 per cent citric acid, sulphur absent, oxygen absent.	Tin	Iron anodic.
6	Iron	0.5 per cent citric acid, sulphur absent, oxygen present.	0.5 per cent citric acid, agar-agar bridge.	0.5 per cent citric acid, sulphur present, oxygen absent.	Tin	Iron cathodic

The potential between tin and iron was never very great, and the polarity could frequently be changed by bubbling the gas through one electrode vessel and not through the other. The potential difference was measured at frequent intervals for 20 days. The potential was variable and drifted one way or the other depending upon the rate at which oxygen or nitrogen was bubbled through the vessels. The polarity was quite generally that indicated in Table 2. Since the condition of the surface of the electrodes is so very important, the results obtained here should be considered only as indicating a general tendency. It seems that where oxygen is present the tendency is for iron to be cathodic and where hydrogen sulphide is present the general tendency is for iron to be anodic. This is in general agreement with the normal electrode potentials of tin and of divalent and trivalent iron (*10*). Divalent iron stands above tin, whereas trivalent iron stands below tin in the electrochemical series. The experiments indicate that in ordinary canning operations tin is anodic to iron, but where hydrogen sulphide is present the ferric salts are reduced to the ferrous form, and iron may become anodic to tin. Oxygen also acts to prevent the formation of a polarizing film of hydrogen. The spray residue therefore tends to reverse the polarity between tin and iron and makes the iron the dissolving electrode of a galvanic cell wherever the tin does not completely cover the iron.

The galvanic action between iron and tin does not account for the increased liberation of gas when sulphur is present. When iron is anodic and is being dissolved by an acid the hydrogen must be liberated at the cathode. Since in these experiments tin has never been observed to liberate hydrogen, it would appear that the hydrogen is liberated from the iron directly as a result of localized chemical action upon the iron. When free sulphur was present the liberation of gas from the particles of sulphur has been observed. In this case the electrochemical action was between iron as anode and sulphur as cathode.

The corroding action of an electrolyte is generally slowed down by the accumulation of ions of the corroding metal, and the corrosion process may even be stopped altogether. In this case hydrogen sulphide prevents the accumulation of ferrous and ferric ions and therefore maintains the tendency to dissolve at its maximum value. This must increase the tendency to liberate hydrogen or hydrogen sulphide and also tends to make iron anodic to tin.

POLARITY OF IRON AND TIN AS RELATED TO CORROSION

To determine just how tin and iron react in an electrolyte when sulphur is present, an experiment was performed wherein 700 c. c. of 0.5 per cent citric acid was placed in each of four ordinary fruit jars. The acid was boiled just previous to being placed in the jars. To each jar 0.3 gm. of flowers of sulphur was added. Plates of iron and tin were introduced into these jars as follows: In the first, iron alone; in the second, tin alone; in the third, tin and iron not in contact; and in the fourth, iron and tin placed firmly in contact. The jars were then heated 20 minutes in a steam bath, after which the tops were clamped down and the jars sealed as in ordinary canning operations. They were thus very nearly free from oxygen. After the jars had been stored for 134 days the metal plates were removed, dipped for an instant in hydrochloric acid, then washed with water, wiped with a dry towel, dried for a short time in an oven, and weighed.

In the first jar the iron (alone) lost 1.126 gm.; in the second the tin (alone) lost 0.172 gm. In the third jar, with tin and iron not in contact, the tin lost 0.12 gm. and the iron lost 1.673 gm.; in the fourth, with tin and iron placed firmly in contact, the tin lost 0.013 gm., and the iron lost 2.198 gm.

It is therefore evident that the presence of sulphur causes intense corrosion of the iron. The tin corrodes very much less than the iron. The tin in contact with the iron does not protect it, but on the other hand the tin is protected to some extent from corrosion by contact with iron.

This is the exact reverse of the relationship obtained with the same metals when immersed in peach juice and in citric acid without the addition of sulphur. This seems satisfactorily explained by the relative positions of tin and of divalent and trivalent iron in the electrochemical series. With an oxidizing acid and with more or less oxygen present, as in the peach juice, ferric iron may be present, which would make the tin the dissolving electrode. If hydrogen sulphide is present any ferric iron would be reduced to ferrous iron, and therefore the iron would be the dissolving electrode, or anodic to tin when in contact with it. It seems that where oxygen or an oxi-

dizing acid is present a certain degree of passivity is conferred upon the iron, and the addition of hydrogen sulphide destroys this passivity. The effect of oxygen and oxygen-supplying acids may also partly explain some of the results of Mantell and Lincoln (*6*), of Lueck and Blair (*4*), and of Kohman (*3*). Of course many factors are concerned, such as temperature, nature of the electrolyte, concentration of the metallic ions in the electrolyte, the character of the surfaces of the corroding metals, and their overvoltage values. From these experiments, however, it is clear that sulphur is of considerable importance in canning operations, since many vegetables are known to liberate hydrogen sulphide during sterilization. Even immature fruits may liberate small quantities of hydrogen sulphide when heated. Much more work will be required to determine the exact effect of sulphur with different products and to control its action favorably in the canning process.

SUMMARY

Sulphur-spray residues are sometimes rather difficult to remove from the surface of peaches. The presence of this sulphur in the can causes the formation of hydrogen sulphide and hydrogen gas, with the consequent swelling of the can.

Washing in cold water and even in hot water does not always prove effective in removing the spray material. Dipping the fruit in hot dilute lye for a few seconds and then washing the fruit with jets of cold water has proved effective in the two seasons in which it has been used. It has been found possible in this way to handle rather soft fruit without disintegrating it.

Almost all forms of sulphur in the acid juices of the peach cause the swelling of the can. Lime-sulphur spray, hydrogen sulphide, sodium sulphide, sodium sulphite, sodium thiosulphate, flowers of sulphur, ferrous sulphide, stannous sulphide, and sulphurous acid have caused swelling of tin cans in experimental packs.

Aside from causing the can to swell sulphur has a corroding effect upon it. In addition to itself combining with the metal, it seems to act as a catalytic agent, greatly accelerating the action of the natural fruit acids upon the metal of the container.

In the presence of organic acids most forms of sulphur will cause corrosion and swelling of the can, but in the absence of these no swelling of the can occurs. However, if the sulphur is in such form that it can combine with the metal it will corrode the can in the absence of acid. Thus, flowers of sulphur corrodes the can whether acid is present or not; ferrous sulphide does not cause appreciable corrosion in absence of acid, but in the presence of acid it greatly corrodes the can.

The action of organic acids upon tin does not result in the liberation of hydrogen, but hydrogen is liberated from iron by organic acids. Thus it seems that if the iron in the container could be completely covered with tin the possibility of gas formation would be much less.

The electrochemical theory of corrosion seems to offer a rather adequate explanation of the phenomena here observed.

In ordinary canning the acid juices of the peach act as an electrolyte in which iron is cathodic to tin when they are in contact. If hydrogen sulphide is present this relationship is reversed, and iron becomes anodic and tin cathodic.

In the presence of oxygen or an oxidizing acid, iron is usually cathodic to tin, whereas if a reducing agent such as hydrogen sulphide is present, the iron is anodic to tin when they are in contact. This relationship, together with the fact that hydrogen sulphide accelerates the liberation of hydrogen from iron, seems to account completely for the swelling of the cans in the cases here described.

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